Appendix 2: Graph that depicts trends in relative population density among permanent study plots in the western Mojave Desert and a map of the same area that depicts an analysis of the likelihood of finding a live desert tortoise (from Tracy et al. 2004)

4.2.2 Trends Range-wide (East and West)

Permanent study plots that have been sampled for an extended period, from which data were used in the original Recovery Plan, and can be divided into those in the eastern and western part of the desert tortoise range (Table 4.4), as was done in the original Recovery Plan. When the 1994 Recovery Plan was written, there were documented population declines in the Western Mojave and this downward trend appears unabated (Fig. 4.6). In addition, there is now a guarded concern for populations in the East Mojave (in California), particularly due to a single recent data point at the Goffs site (Fig. 4.6). This concern has highlighted the need for more data to assess the importance of data points that could either be outliers or could be indicators of new trends. In these areas, desert tortoises appear to be affected by various combinations of threats or the cumulative effects of many threats.

Table 4.4 Study plots from which data were used to assess trends in population size in the original Recovery Plan.

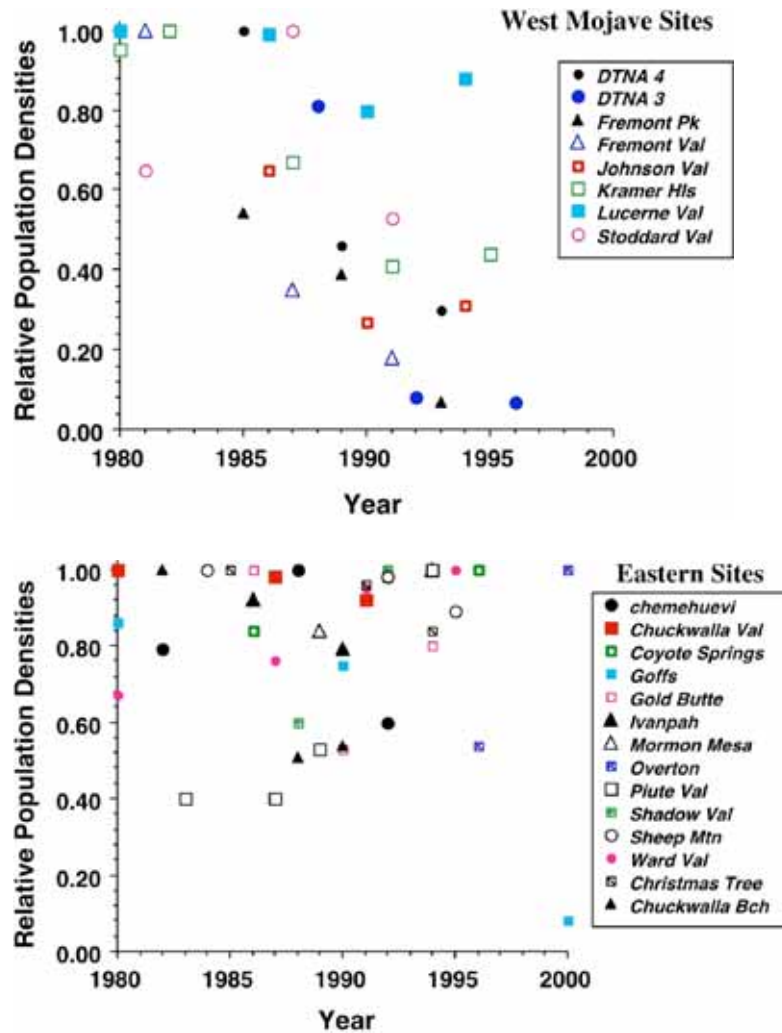| *Eastern*	*Western*
Chemehuevi Valley	Desert Tortoise Natural Area (Interior)
Chuckwalla Bench	Desert Tortoise Natural Area (Visitors Center)
Chuckwalla Valley	Fremont Valley
Ivanpah Valley	Fremont Peak
Upper Ward Valley	Johnson Valley
Christmas Tree	Kramer Mountains
Coyote Springs	Lucerne Valley
Gold Butte	Stoddard Valley
Piute Valley	
Sheep Mountain	
Trout Mountain	

Fig. 4.6 Trends in relative population densities for desert tortoises in the eastern and western permanent study plot sites.

4.2.3 Trend Analyses by Recovery Unit

The DTRPAC analyzed for trends in tortoise population densities at a finer spatial scale than just the eastern and western portions of the listed range (as was done in the Recovery Plan). It is important to recognize that analyzing permanent study plots individually is largely meaningless except to learn about processes only on the plot (generally not valuable for conservation planning). Thus, analyzing permanent study plots cannot give insight into population trends occurring within larger management areas (Manly 1992, MacDonald and Erickson 1994, Underwood 1997) unless the plots are randomly placed within the area for which generalization is needed. Nevertheless, for our analyses, study plots were treated as though they were random samples of regions. Because the permanent study plots actually were not randomly placed (Berry 1984), this somewhat limits the extent to which it is

4.3.4 Conditional Probability of Live Encounter
(distance sampling transects, Western Mojave, 2001).

Resampling

For this analysis the Western Mojave was divided into a grid consisting of 18 cells. Using the 2001 LDS data, the proportion of tortoises that were alive (i.e., live tortoises/[live + dead tortoises]) was then calculated for each cell. A test statistic was then derived for each cell, which consisted of the observed proportion of tortoises that were alive in each cell minus the proportion calculated from all cells combined (0.284).

The test statistics for each of the 18 cells (Table 4.7) were tested for significance using a randomization method. To produce a randomized set of data the 609 transects were randomly reallocated to the 18 cells. This was done 10,000 times. The p-value for the statistic from the ith cell was then the proportion of times that the randomized sets of data gave a value as far or further from zero than the observed test statistic. In addition, a 19th statistic was calculated, which consisted of the maximum of the absolute values of the statistics for the individual cells. This was then used to calculate an overall test of differences between the cells and for all of the data.

As shown in Table 4.7, there are significant results for cells 6, 7, 12, and 16, and for the maximum statistic. There is also a nearly significant result for cell 15. It is more compelling to view the data graphically. Distinct areas, as defined by groupings of points with the same color with lower (red) or higher probabilities (green) of live encounters are clearly identifiable in Fig. 4.20.

Table 4.7 Observed ratios of live to dead tortoises. The P values indicate bins of transects in which the ratios were different from that expected at random. The sign of the observed value indicates the direction of the difference.

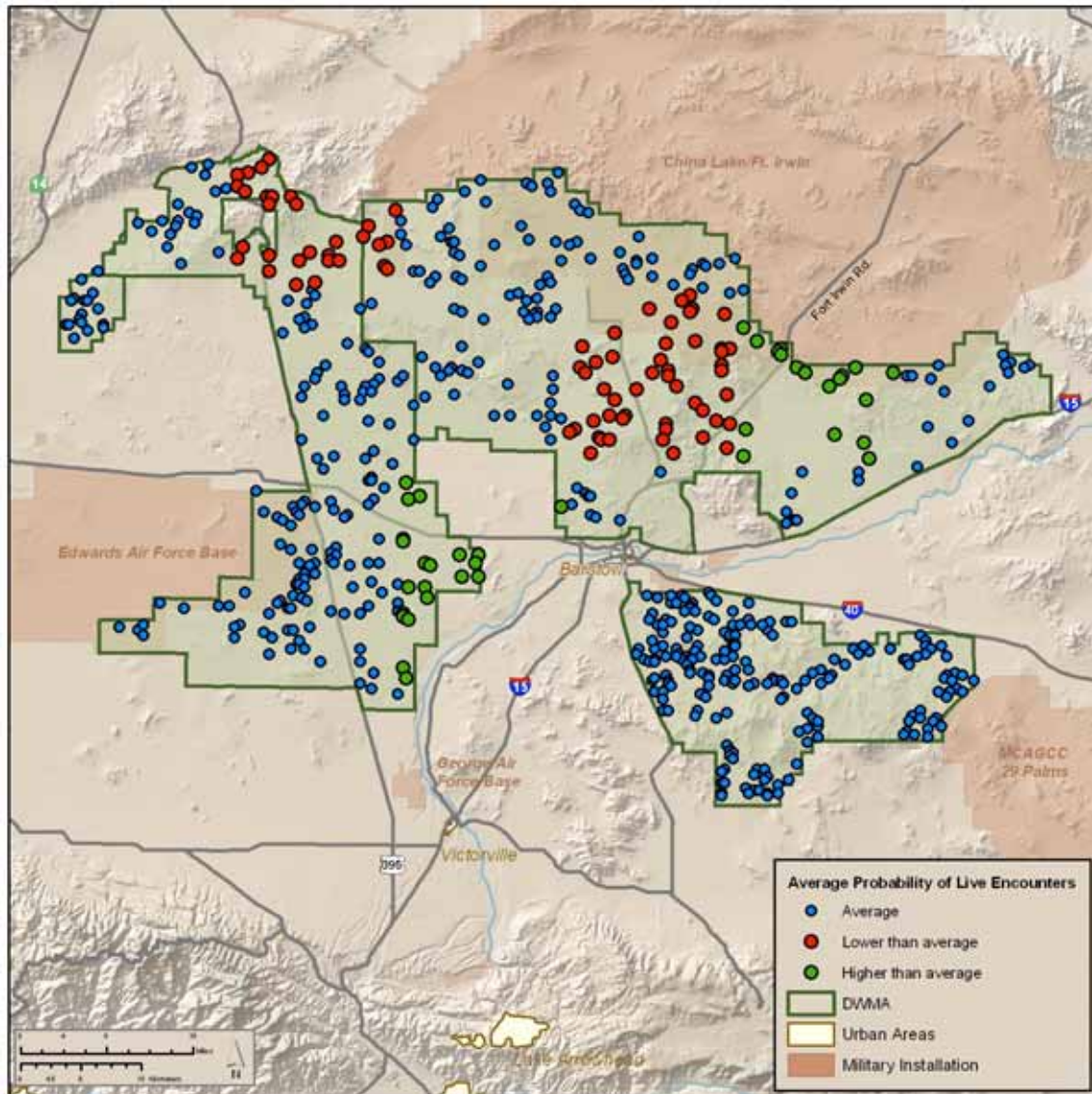| Bin	Observed Value	P-value	Bin	Observed Value	P-value
1	0.08	0.45	10	0.09	0.09
2	-0.13	0.24	11	0.01	0.85
3	0.10	0.47	12	-0.14	0.04
4	0.06	0.30	13	-0.06	0.56
5	0.10	0.47	14	0.05	0.43
6	-0.28	0.002	15	-0.21	0.07
7	0.29	0.008	16	0.52	0.001
8	0.03	0.75	17	0.05	0.54
9	0.05	0.54	18	0.22	0.09
			Max	0.52	0.004

Fig. 4.20 Results from the resampling analysis - Areas depicted in red are points in bins 6 and 12, which had lower than average probabilities of live encounters; green points are bins 7 and 16, which had higher proportions of live animals. Points in all other bins are blue in color.

Logistic Regression

Another analysis was possible based upon logistic regression. The regression calculates the probability of a tortoise being live at a distance E km east and N km north from easting 414493 and northing 3825771 and is given by

$$P(E,N) = \exp(\beta_0 + \beta_1 E + \beta_2 N + \beta_3 E.N + \beta_4 E^2 + \beta_5 N^2)/\{1 + \exp(\beta_0 + \beta_1 E + \beta_2 N + \beta_3 E.N + \beta_4 E^2 + \beta_5 N^2)\}.$$

Data for this analysis were restricted to transects on which both live and/or dead tortoises were observed. Each of these transects then provided one observation on the number of

tortoises that were live in a sample of *n* tortoises. It is possible that higher order polynomial terms are needed in the equation to describe better the spatial changes in the probability of a tortoise being live. This was not investigated.

The following analysis of deviance shows that the model accounts for a significant amount of the variation in the data (Tables 4.8 and 4.9). The mean deviance is much larger than one, indicating that part of the variation in the data is not properly accounted for. This confirms that it would be worth investigating adding higher order polynomial terms into the equation. A kriging surface mapping the conditional probability of being alive in 2001 are presented in Fig. 4.21.

This analysis asks the question, if a tortoise is found on a transect, what is the probability that it is a live tortoise? The region in the northern portion of the Fremont-Kramer DWMA and the northwestern portion of the Superior-Cronese DWMA had noticeably lower probabilities of encountering a live tortoise relative to other portions of the DWMAs.

Table 4.8 Statistical table for the logistic regression analysis.

	df	Mean deviance	Deviance	Deviance ratio	Approx chi pr.
Regression	5	47.8	9.56	9.56	<.001
Residual	300	820.5	2.74		
Total	305	868.3	2.85		

Table 4.9 The estimated coefficients for the logistic regression model.

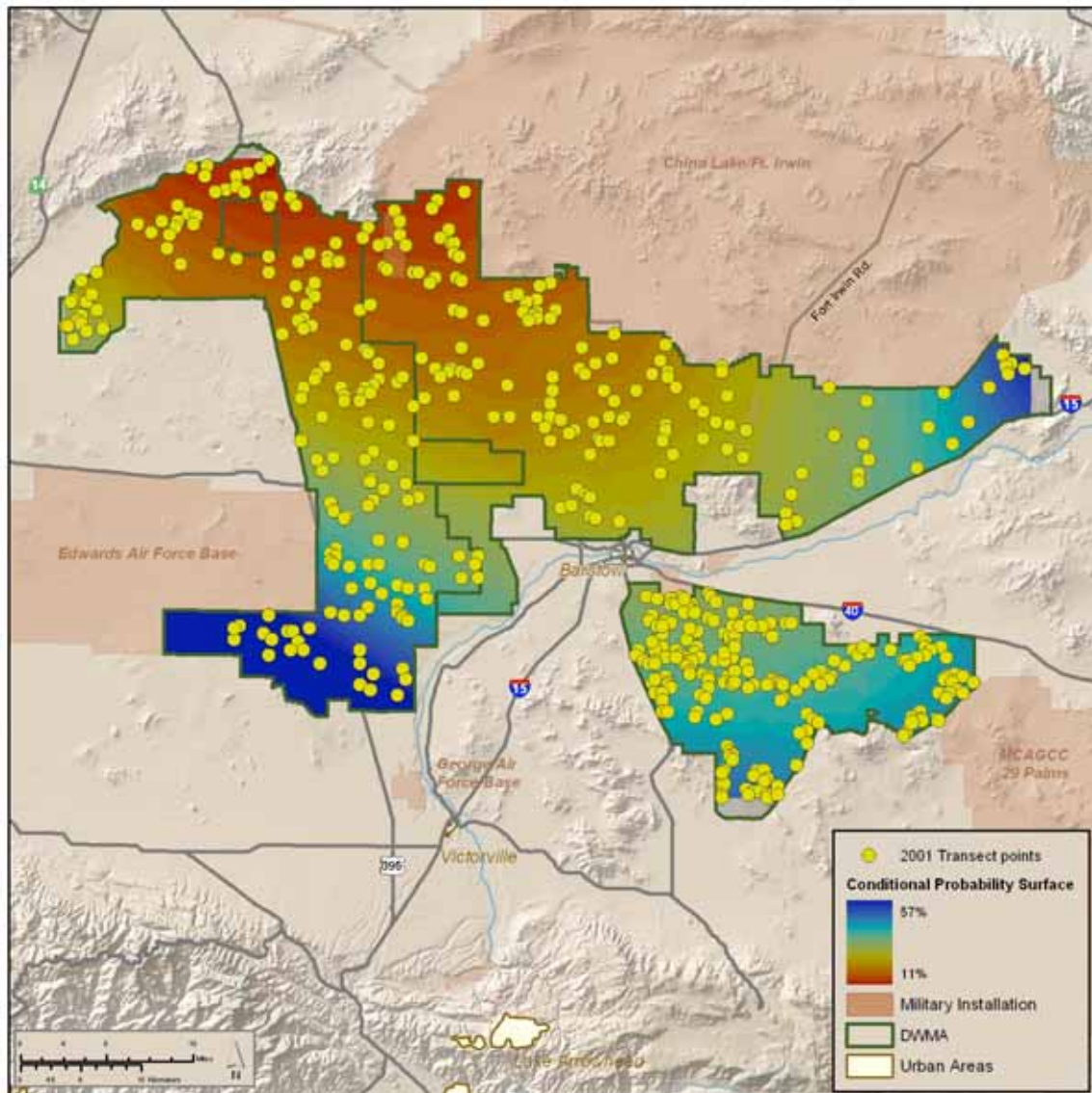|	Estimate	s.e.	t(*)	t pr.
Constant	1.966	0.63300	3.11	0.002
E	-0.02214	0.00506	-4.37	<.001
N	-0.02654	0.00979	-2.71	0.007
EN	0.0000791	0.0000251	3.15	0.002
E2	0.0000480	0.0000133	3.61	<.001
N2	0.0000348	0.0000427	0.82	0.414

Fig. 4.21 Results from the logistic regression analysis. Cooler colors indicate higher probabilities of encountering a live tortoise, and warmer colors indicate a lower probability.

4.3.5 Kernel Analyses
(distance sampling transects, range-wide, 2001).

The analyses presented above are useful for comparisons among DWMAs, but do not indicate *where* within an individual DWMA one would be more likely to find live tortoises. The kernel, cluster, and conditional probability of being-alive analyses presented below however, do indicate *where* within a DWMA one would expect to find live tortoises. This type of within-DWMA spatial analysis requires that the sample transects be significantly spatially random or regularly distributed. As such (for reasons given above), only the 2001 LDS data were used.